

LDCM Geometry Overview

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Overview

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◆ Landsat 7 vs. Landsat 8 Instrument Architecture

- Geometric implications of architecture differences
- Pushbroom vs. whiskbroom
 - ❖ Band-to-band parallax
 - ❖ Yaw steering required
- One instrument vs. two
 - ❖ Reflective/thermal co-registration

◆ Key Geometric Requirements Comparison

- Band registration
- Geodetic accuracy (systematic accuracy)
- Geometric accuracy (Level 1T accuracy)

◆ Data Processing Considerations

- Importance of terrain correction
- Use of GLS ground control and DEM
- Product footprint trimming

◆ Summary

Instrument Architecture Comparison

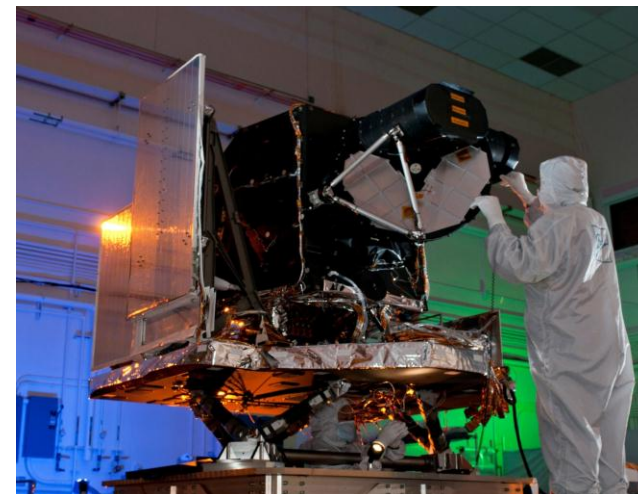
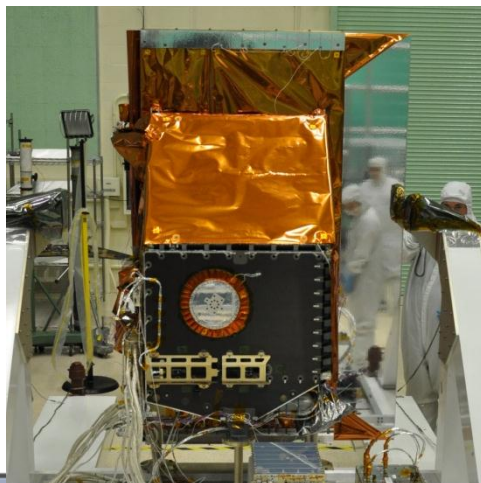
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	Landsat 7 ETM+	Landsat 8 OLI/TIRS
Instrument Architecture	Whiskbroom Scanner	Pushbroom
Moving parts (for normal imaging)	Scan Mirror & Scan Line Corrector	None*
Internal Image Geometry Stability	Challenging with jitter and scan mechanism	Good with lack of moving parts
Focal Planes	Prime & Cold	14 (OLI) / 3 (TIRS) Sensor Chips

*TIRS scene select mirror does not move during normal imaging.



**Thermal
Infrared
Sensor**

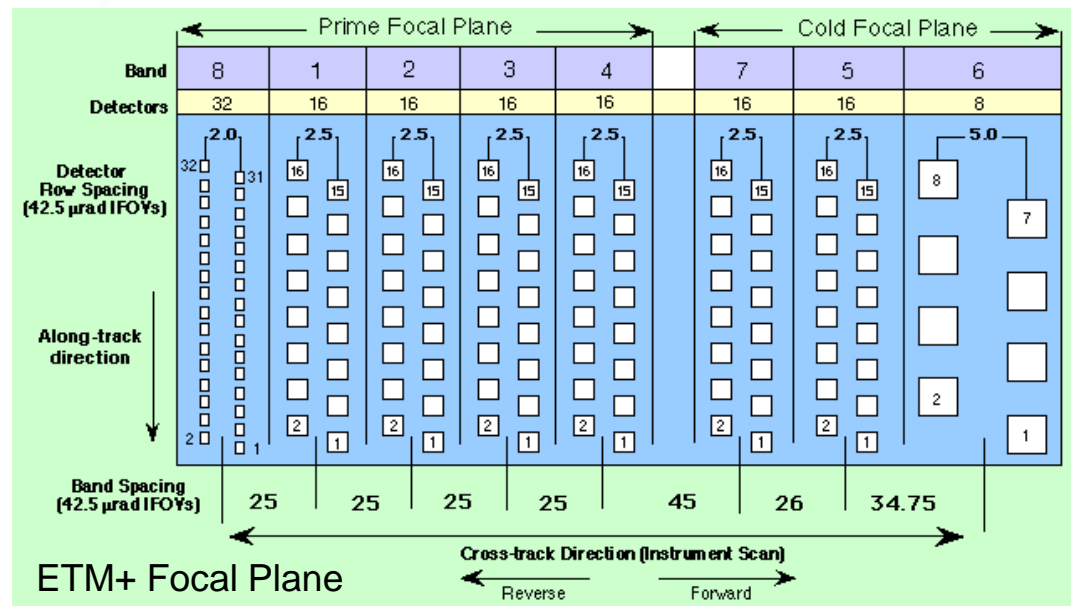


Operational Land Imager

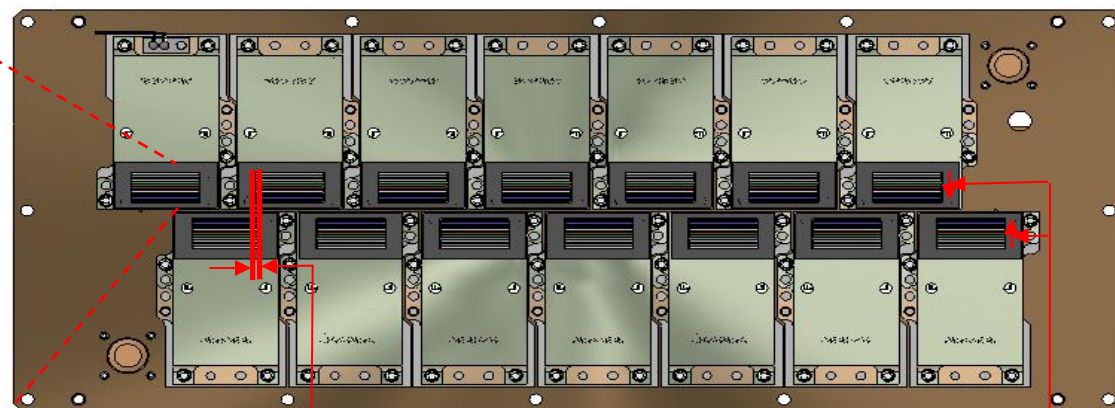
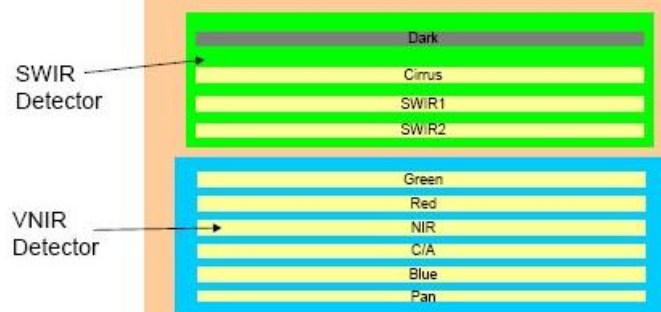
OLI/ETM+ Focal Plane Layout Comparison

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	Landsat 7 ETM+	Landsat 8 OLI
Spectral Band Distribution	Along-scan (Cross-track)	Along-track
Time for all bands to view target	2 msec	1.1 sec
Detector Sample Time	9.6 μ sec	4.2 msec

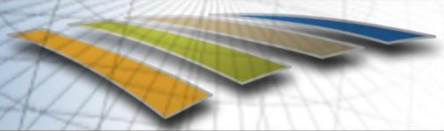


OLI Sensor Chip Assembly



SCA-to-SCA overlap

Band order is reversed
in even and odd SCAs



Key OLI Focal Plane Characteristics

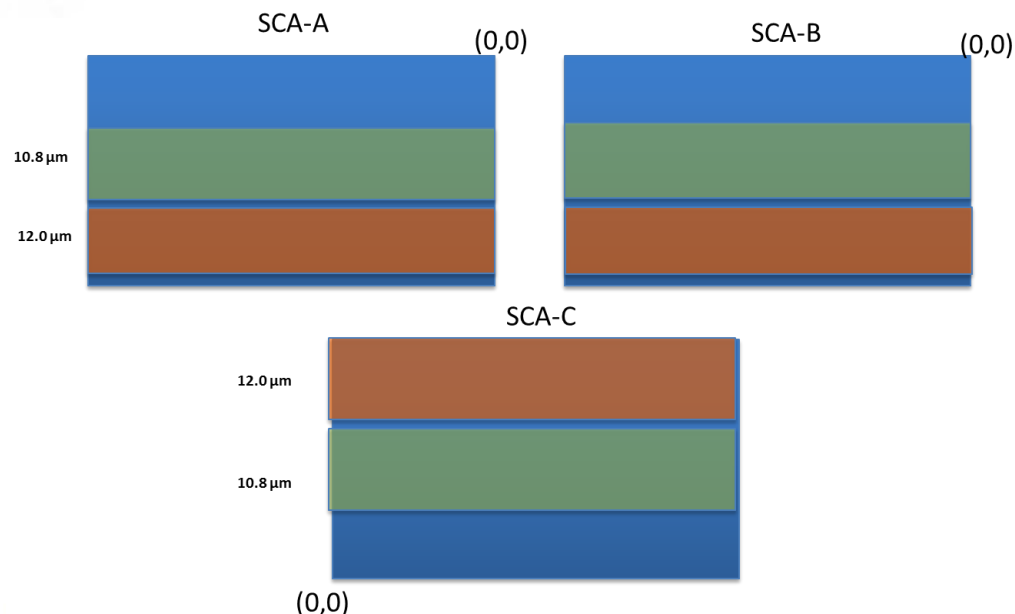
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- ◆ **Fourteen separate Sensor Chip Assemblies (SCAs) are required to cover the full Landsat field of view**
- ◆ **Along-track separation of spectral bands leads to ~1.1 second time delay between leading and trailing bands**
 - This creates a small, but significant, terrain parallax effect between spectral bands, making band registration more challenging
- ◆ **The along-track dimension of the OLI focal plane also makes it desirable to “yaw steer” the spacecraft**
 - The spacecraft flight axis is aligned with the ground (Earth fixed) velocity vector rather than the inertial velocity vector to compensate for cross-track image motion due to Earth rotation
 - Requires a small spacecraft yaw maneuver that varies continuously over the orbit, from zero near the poles to ~4 degrees at the equator
 - Accounts for Earth rotation during the time delay between leading and trailing bands and leading and trailing SCAs

ETM+/TIRS Focal Plane Layout Comparison

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	Landsat 7 ETM+	Landsat 8 TIRS
Spectral Band Distribution	Along-scan (Cross-track)	Along-track
Time for all bands to view target	2 msec	1.9 sec
Detector Sample Time	19.2 μ sec	14.3 msec



Scene
Select
Mechanism

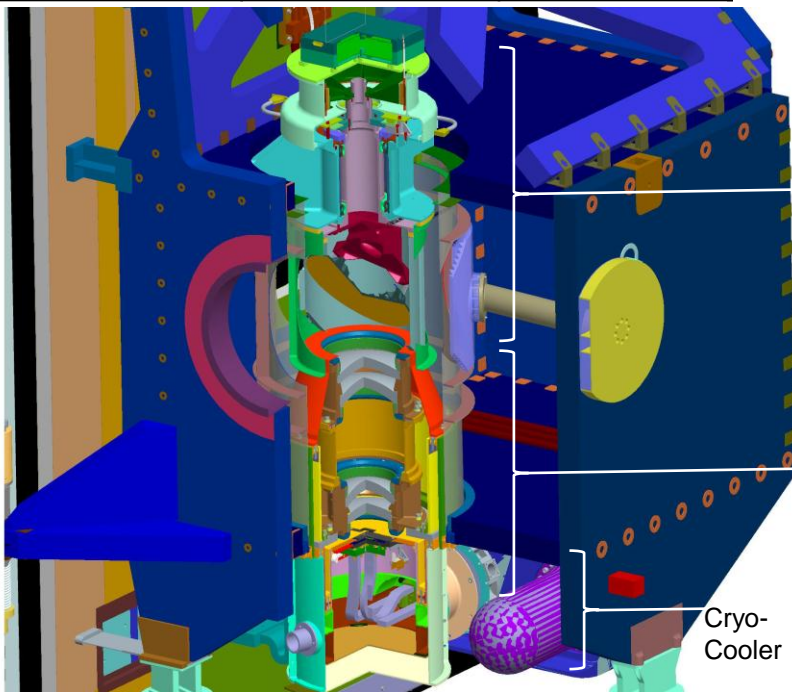
Telescope
/ FPA

Cryo-
Cooler

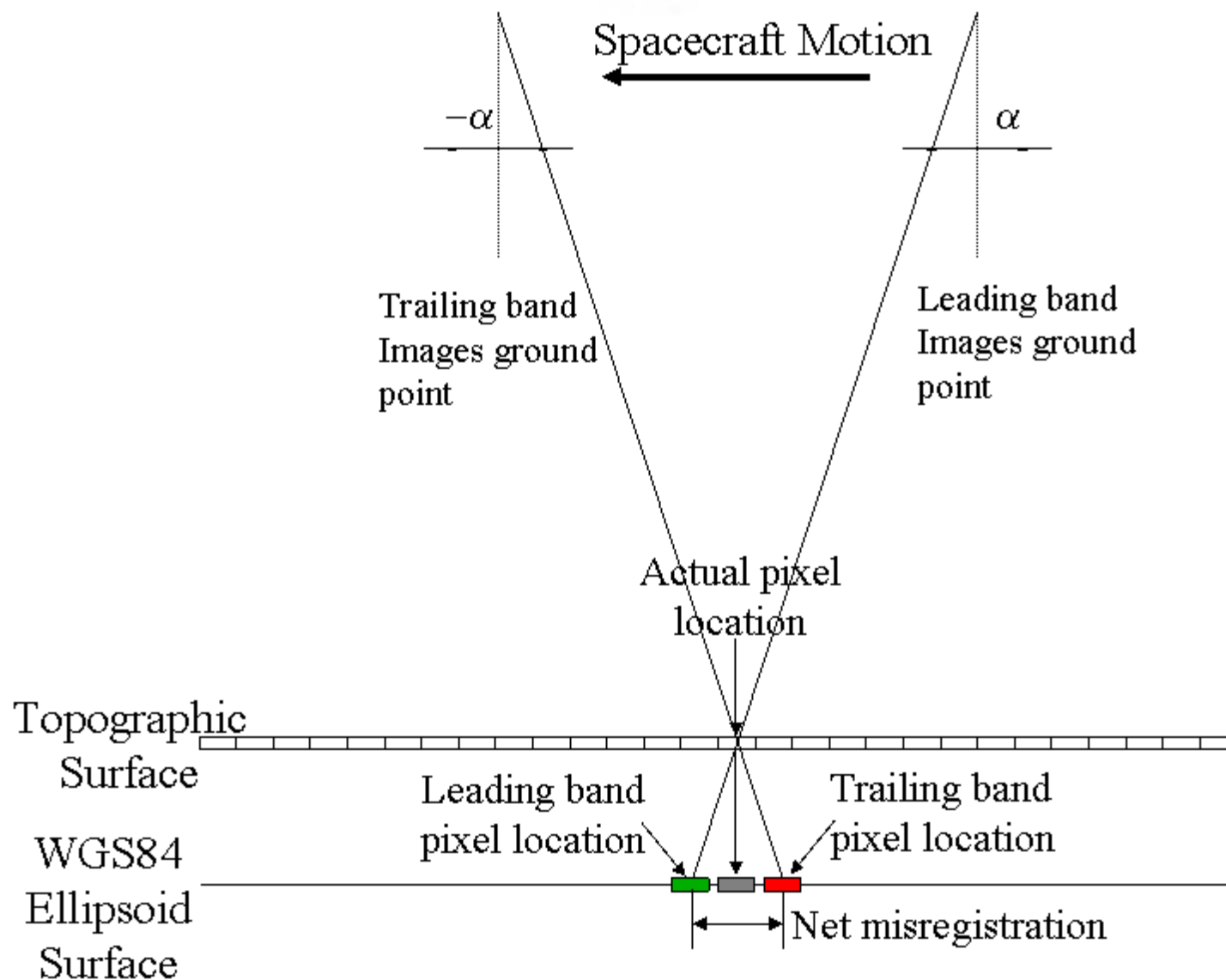
Time between leading and trailing SCAs for 10.8 mm band = 9.2 sec

Time between leading OLI and trailing TIRS band = 6.6 sec (worst case)

Note: Parallax effect is about 1% of the target elevation knowledge error per second of time offset.



Band-to-Band Terrain Parallax Effect

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L7 and L8 Geometric Requirements Summary

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Requirement	L7 Specification	L7 Performance	L8 Specification
Band Registration Accuracy	8.4 m LE90 (reflective) 16.8 m LE90 (emissive)	3.0 m LE90 (reflective) 11.8 m LE90 (emissive)	4.5 m LE90 (OLI) 18.0 m LE90 (TIRS) 30.0 m LE90 (OLI/TIRS) (see note 1)
Absolute Geodetic Accuracy	536.5 m CE90 (see note 2)	45-190 m CE90 (see note 3)	65 m CE90
Relative Geodetic Accuracy	N/A	17 m CE90	25 m CE90
Image Registration Accuracy	12 m LE90	10.5 m LE90 (see note 4)	12 m LE90
Geometric (Terrain Corrected) Accuracy	N/A	15 m CE90 (see note 5)	12 m CE90

Notes:

- (1)OLI/TIRS registration limited by instrument co-alignment stability.
- (2)Specified as 250 meters 1σ .
- (3)Varied with gyro state of health.
- (4)Bumper mode performance.
- (5)Relative to GLS control base.

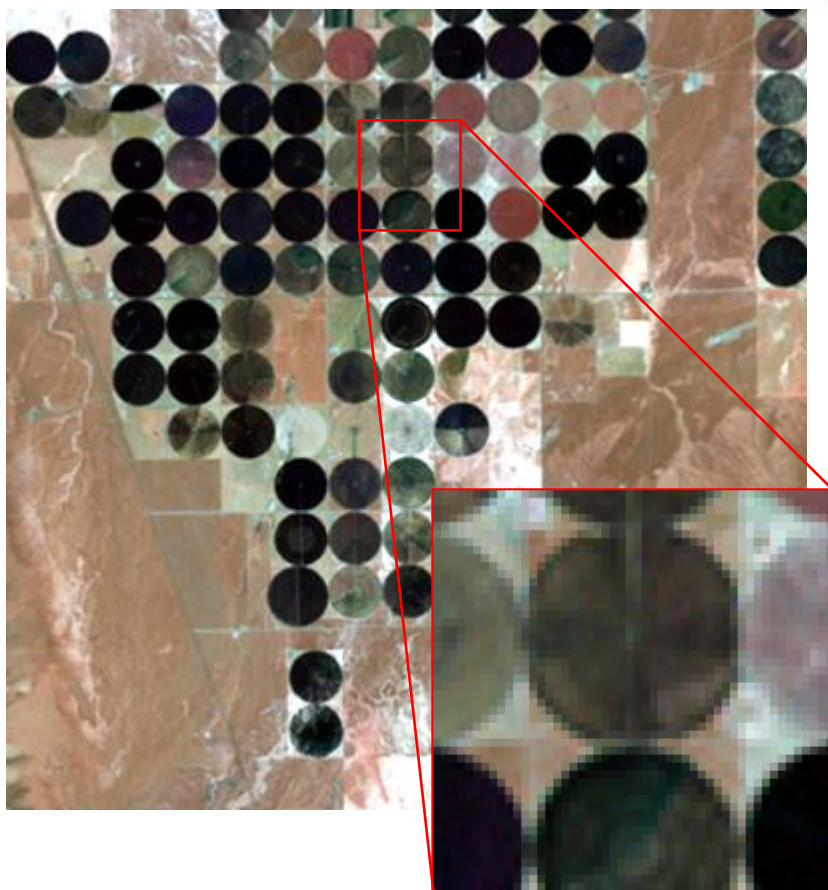
L7/L8 Comparison Key Points

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- ◆ **Most L8 specifications are tighter than their L7 counterparts, reflecting actual L7 performance and the expected benefits of improved geometric stability offered by a pushbroom sensor architecture.**
 - The lack of a moving scan mirror and the associated jitter should lead to improved internal image accuracy.
 - A spacecraft with Global Positioning System navigation and modern star trackers should provide geolocation accuracy as good as or better than Landsat 7.
- ◆ **Some of the band registration accuracy requirements are exceptions to this (e.g., emissive to reflective registration).**
 - Band registration is challenging for L8 due to the longer time required for targets to be viewed by all spectral bands.
 - ❖ Leads to band-to-band terrain parallax effects.
 - ❖ Increases sensitivity to short-term attitude stability.
 - Reflective/emissive registration is even more challenging due to having separate instruments, each with its own within-orbit thermal alignment variation profile.
- ◆ **All L8 products will be terrain corrected to compensate for the parallax inherent in the architecture, to maintain band registration accuracy.**

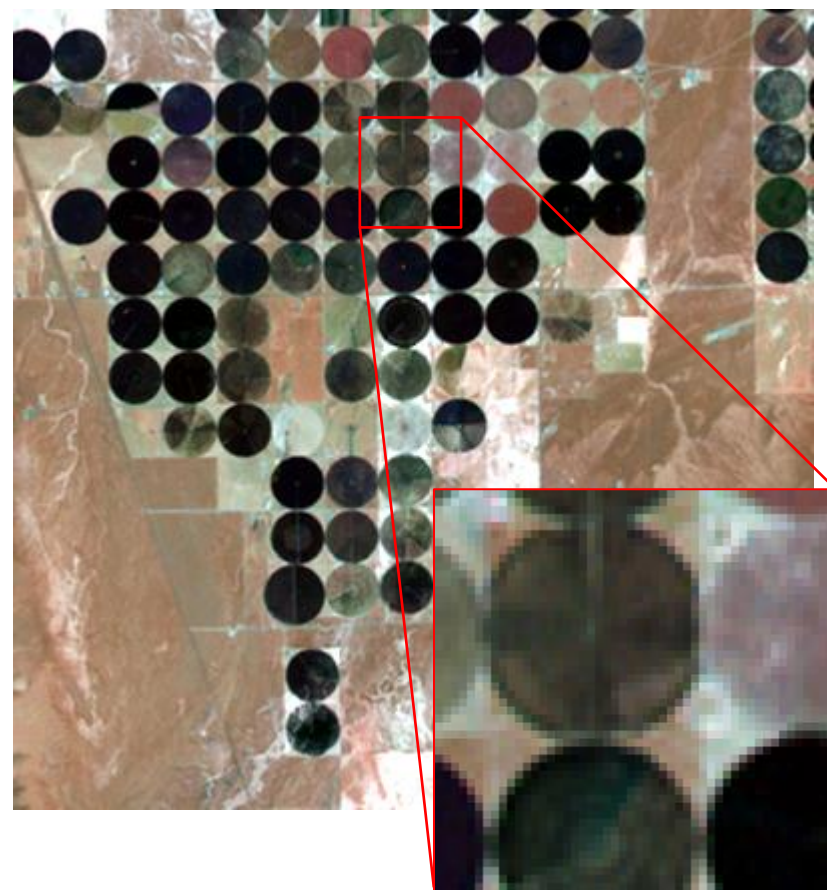
Processing With and Without Terrain Correction

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♦ L1T registration performance (worst-case band pair):

- Cross-track: 3.7 m (LE90)
- Along-track: 3.2 m (LE90)



♦ L1P registration performance (worst-case band pair):

- Cross-track: 7.7 m (LE90)
- Along-track: 33.4 m (LE90)

Ground Control and DEM Data

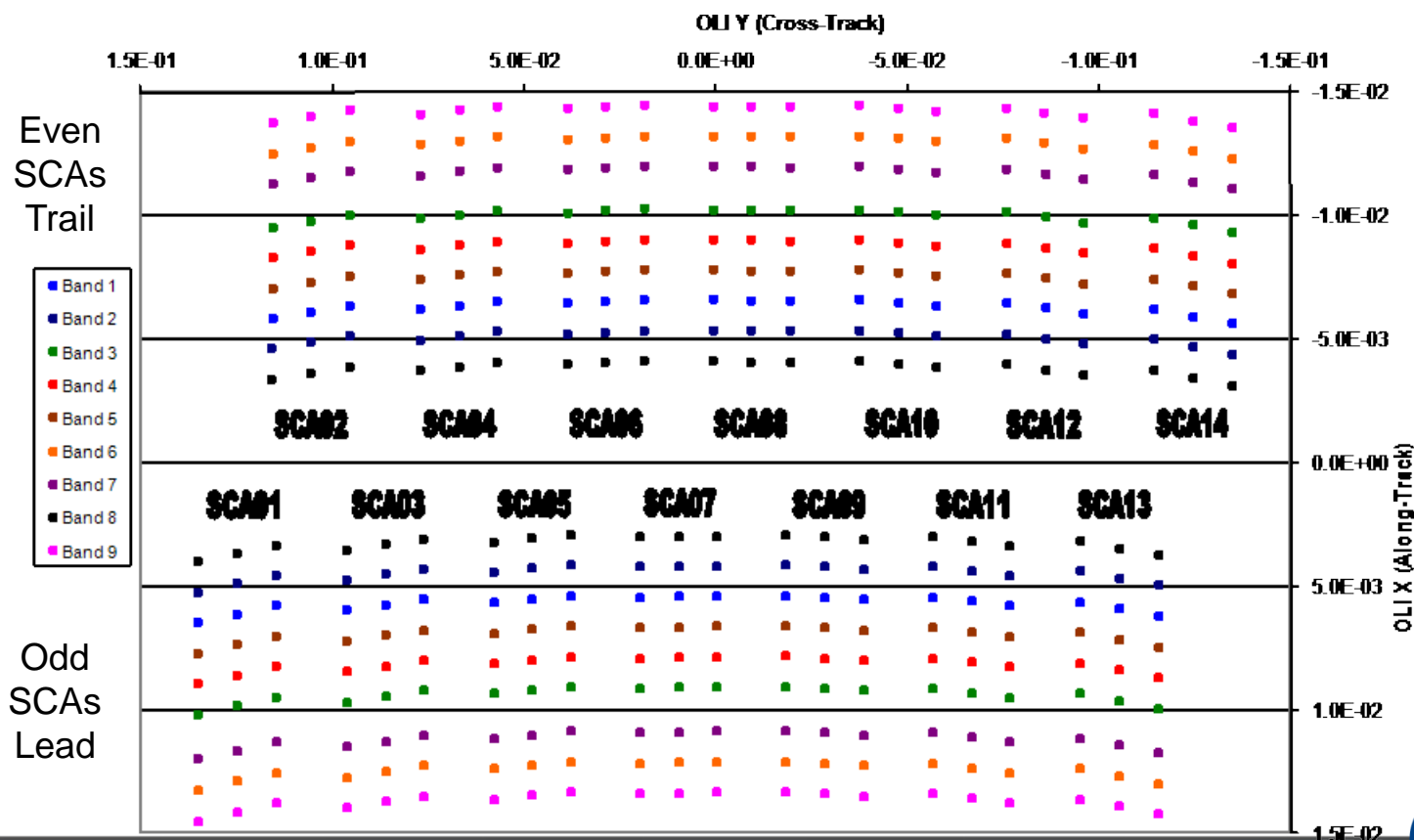
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- ◆ **The 12m LE90 geometric accuracy specification applies to data that have been corrected using ground control and digital elevation data.**
 - Assumes GPS-quality ground control and SRTM-quality elevation data are used.
- ◆ **As a practical matter, GPS-quality ground control is not available globally, so this specification is more realistically interpreted as registration accuracy to the best available ground control source.**
 - This control source for L8 product generation will be the Global Land Survey of 2000 (GLS2000) data.
 - Given the GLS2000 data accuracy limitations (20 meters RMSENet or 30.3 meters (CE90)), using it as control for L1T data products cannot be expected to yield 12 m (CE90) absolute (WGS84) accuracy globally, but it will ensure that the OLI data are all registered to a common, internally consistent, reference system.
- ◆ **Standard L1T processing will use the GLS2000 DEM.**
 - Based on SRTM data where available, but best available DEM elsewhere.
- ◆ **The goal is to provide consistency with the existing Landsat data archive, which is based on the GLS framework.**
- ◆ **We plan to use the absolute accuracy of L8 to improve that framework over time.**

L1T Scene Trimming

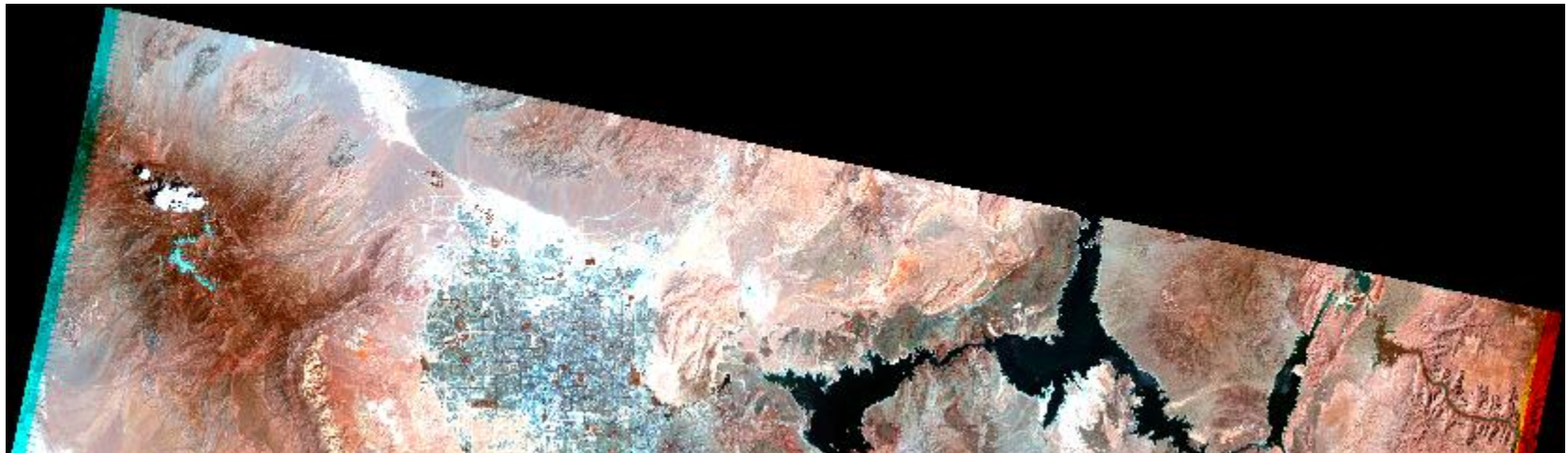
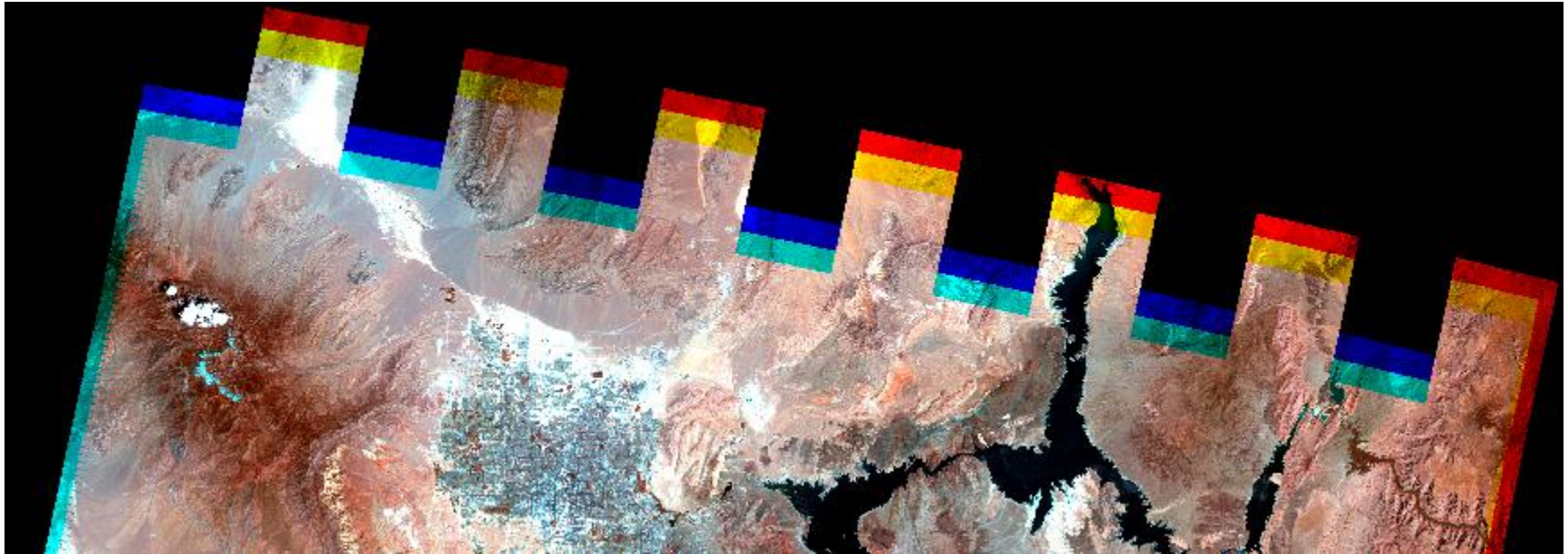
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- ◆ **Product coverage will be trimmed to remove leading/trailing data from odd/even sensor chip assemblies (SCAs)**
 - Reduces product size
 - Makes product more like heritage products (see next chart)
 - Still provides full WRS-2 scene coverage



Effect of SCA Trimming in L1T

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Summary

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◆ Replace ETM+ whiskbroom with OLI/TIRS pushbroom

- Improves SNR
- No scanning mechanisms to worry about (e.g., ETM+ scan line corrector)
- Increased time delay between bands leads to parallax which makes band registration more difficult
- Parallax between bands and between sensor chips makes terrain correction mandatory

◆ Replace single instrument with two payloads

- Get an additional thermal band
- Makes reflective/emissive registration even more challenging due to thermally induced instrument-to-instrument alignment variations

◆ Spacecraft improvements

- On-board GPS and modern star trackers improve position and attitude knowledge
 - ◆ Better geolocation accuracy
- Will not have immediate impact on products as they will be registered to the GLS control base
- Will allow us to improve geometrically weak areas in the GLS